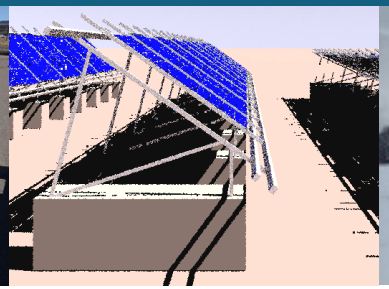
SAND2024-13287C

PVPerformance MODELING COLLABORATIVE

Sandia National Laboratories

Blind Photovoltaic Performance Modeling Comparison of Commercial Software

Lelia Deville, Marios Theristis, Kevin Anderson, Terrence L. Chambers, Juergen Sutterlueti, Karel De Brabandere, Felix Perez Cicala, Javier Lopez Lorente, Brian Mirletz, Anja Neubert, Maitheli Nikam, Michele Oliosi, Matthew Prilliman, Kurt Rhee, Branislav Schnierer, Bruno Wittmer

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Motivation & Previous PVPMC Blind Modeling Studies

- Blind comparisons allow modelers to compare their models/software and skills to others from a wide variety of disciplines without causing any bias from using known datasets

- This PVPMC comparison:
  - Has a larger system size than considered in the previous comparison
  - Includes data at hourly and sub-hourly intervals
  - Software providers were invited separately to observe variations between them in greater detail
  - 7 unique companies participated including a 1-on-1 survey

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RESEARCH ARTICLE

PROGRESS IN PHOTOVOLTAICS WILEY

Blind photovoltaic modeling intercomparison: A multidimensional data analysis and lessons learned

Marios Theristis[1] | Nicholas Riedel-Lyngskær[2] | Joshua S. Stein[1] | Lelia Deville[1] | Leonardo Micheli[3] | Anton Driesse[4] | William B. Hobbs[5] | Silvana Ovaitt[6] | Rajiv Daxini[7] | David Barrie[8] | Mark Campanelli[9] | Heather Hodges[10] | Javier R. Ledesma[11] | Ismael Lokhat[12] | Brendan McCormick[13] | Bin Meng[14] | Bill Miller[10] | Ricardo Motta[15] | Emma Noirault[16] | Megan Parker[10] | Jesús Polo[17] | Daniel Powell[18] | Rodrigo Moretón[19] | Matthew Prilliman[6] | Steve Ransome[20] | Martin Schneider[21] | Branislav Schnierer[22] | Bowen Tian[14] | Frederick Warner[23] | Robert Williams[24] | Bruno Wittmer[25] | Changrui Zhao[26]

Correspondence
Marios Theristis, Sandia National Laboratories, Albuquerque, NM, USA.
Email: mtheris@sandia.gov

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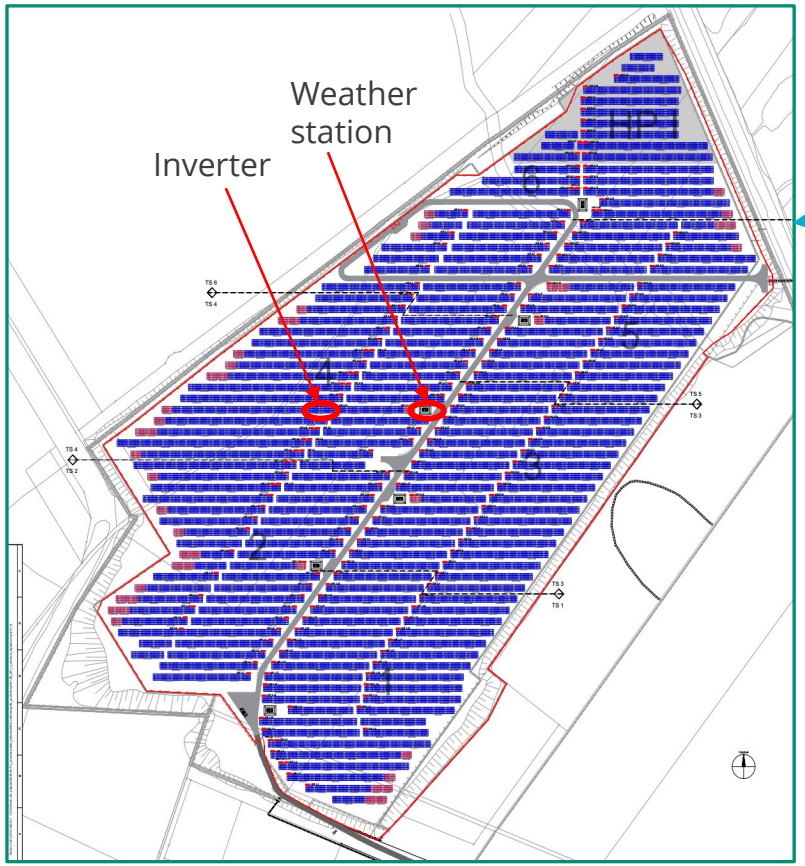
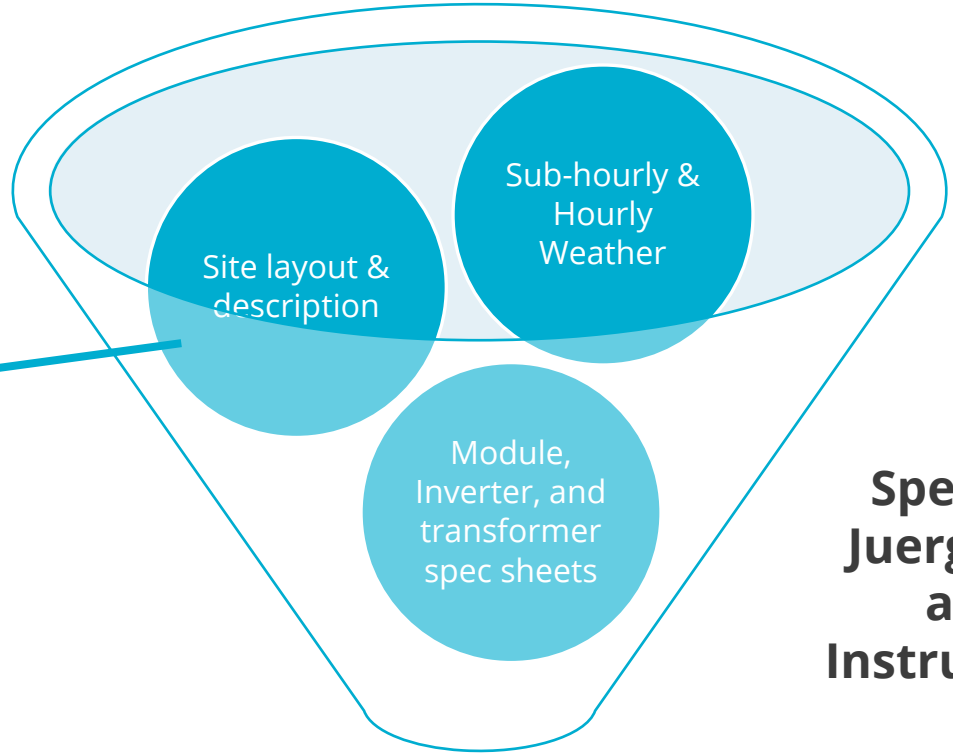
Abstract
The Photovoltaic (PV) Performance Modeling Collaborative (PVPMC) organized a blind PV performance modeling intercomparison to allow PV modelers to blindly test their models and modeling ability against real system data. Measured weather and irradiance data were provided along with detailed descriptions of PV systems from two locations (Albuquerque, New Mexico, USA, and Roskilde, Denmark). Participants were asked to simulate the plane-of-array irradiance, module temperature, and DC power output from six systems and submit their results to Sandia for processing. The results showed overall *median* mean bias (i.e., the average error per participant) of 0.6% in annual irradiation and −3.3% in annual energy yield. While most PV performance modeling results seem to exhibit higher precision and accuracy as compared to an earlier blind PV modeling study in 2010, human errors, modeling skills, and derates were found to still cause significant errors in the estimates.

KEYWORDS
blind comparison, modeling, performance, photovoltaic, yield modeling

System 1: Germany

14.5 MW plant with fixed-tilt monofacial modules with half-cut cells





Modeled module temperature, inverter and site power at DC & AC levels

Special thanks to Juergen Sutterlueti and Gantner Instruments for data provision

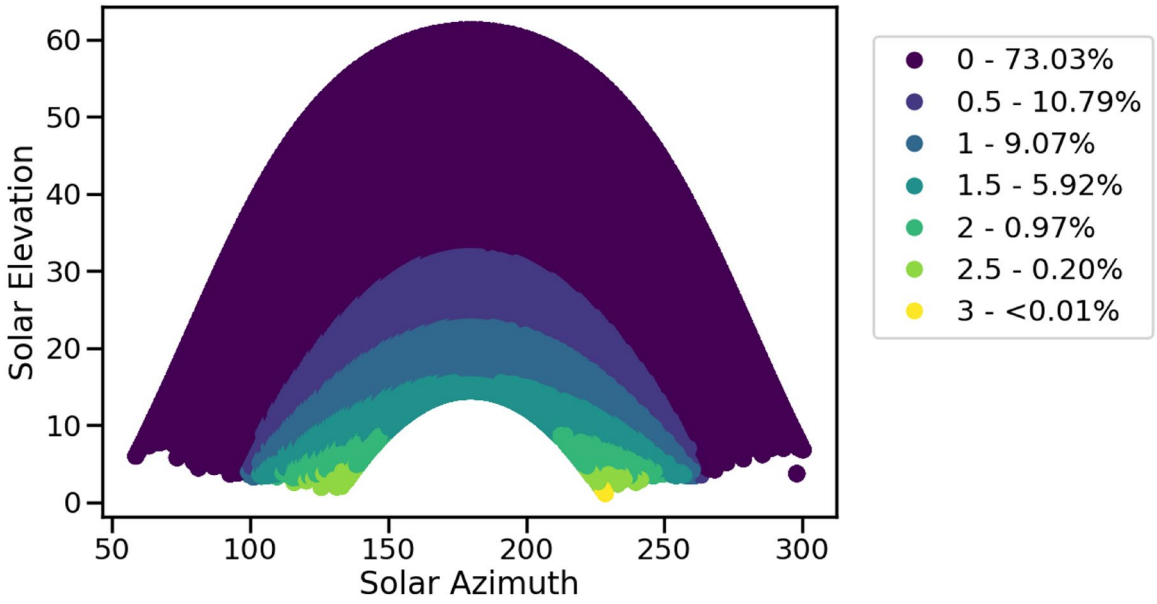
Gantner instruments

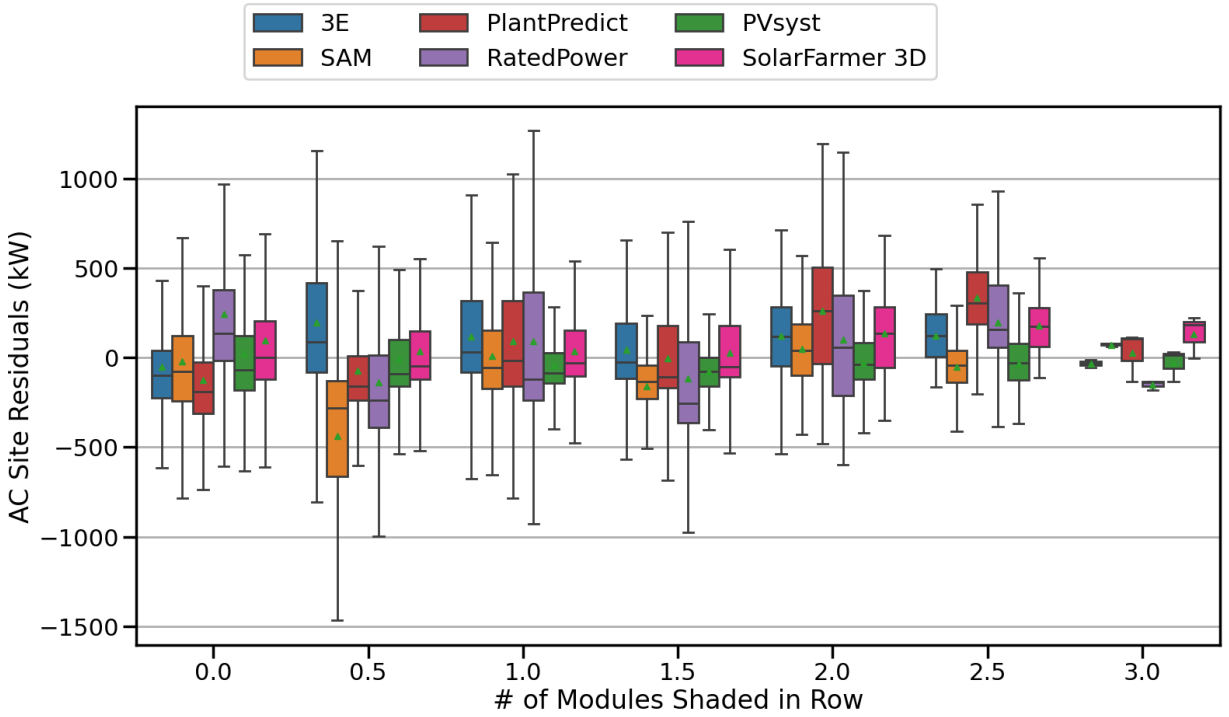
System 2: Albuquerque

15.4 kW fixed-tilt system in Albuquerque

- Files Available:
  - Sub-hourly & hourly weather
  - System configuration & description
  - Module & inverter spec sheets
  - IAM+NMOT report, IEC 61853-1 matrix, & PAN file from CFV Labs
- Software companies modeled:
  - POA
  - Module temperature
  - DC system power

System Shading by Shaded Fraction

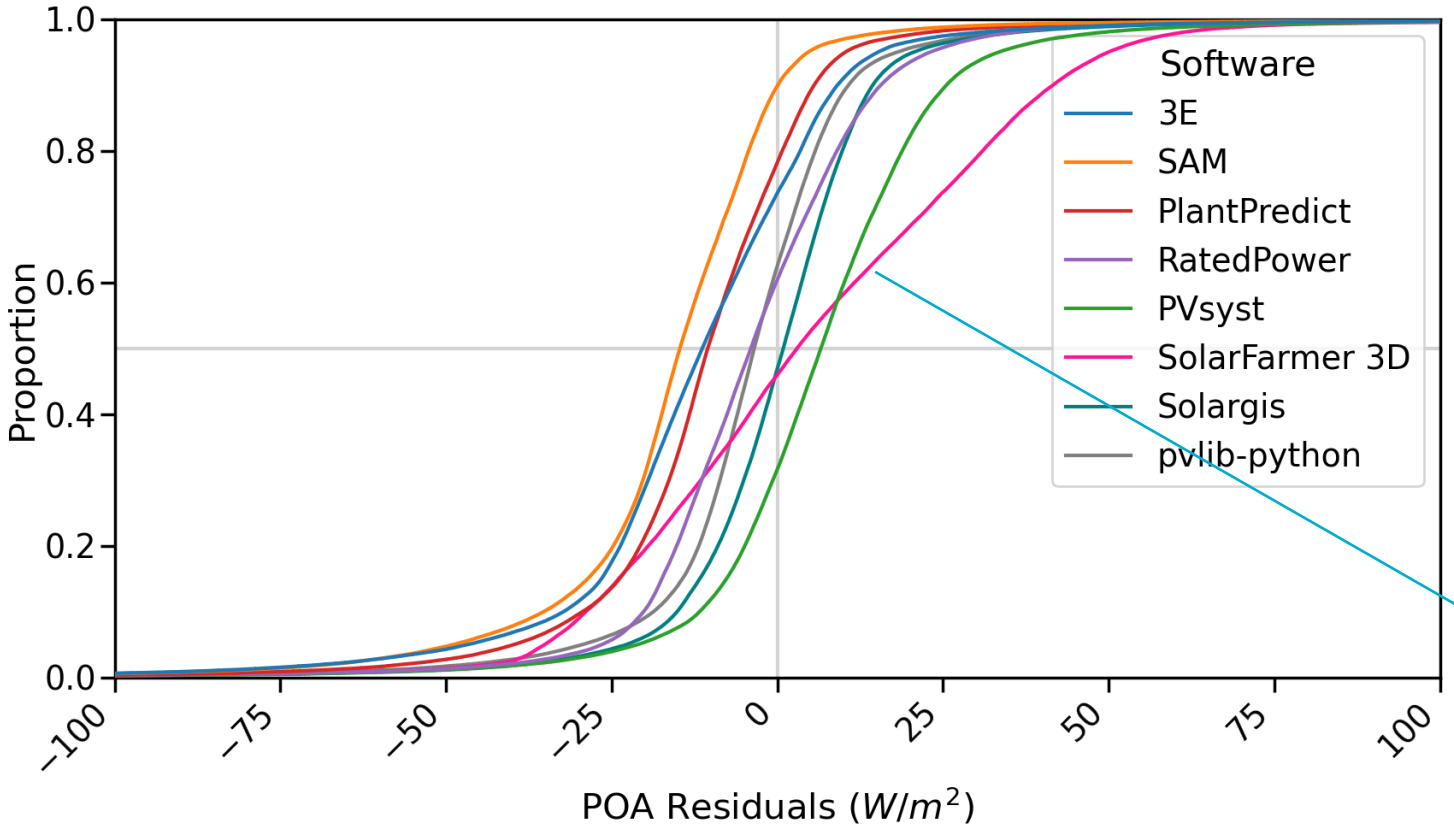




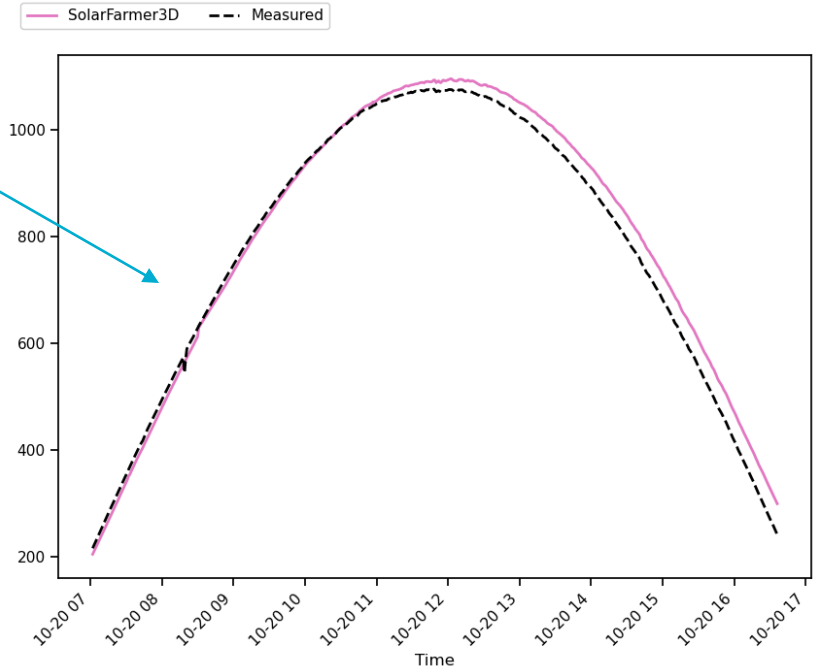
- Median AC site residuals within ±250 kW
- SolarFarmer and PVsyst software consider shading in greater detail
- SAM, PlantPredict, RatedPower, 3E do not seem to account for half-cut cell modules [**to be verified**]

Sub-hourly Germany, 14.5 MW

Perez Transposition Model



Although same Perez *allsitescomposite1990* model, median residuals varied from -14.65 W/m² to 6.06 W/m²; ~ 2.3% delta

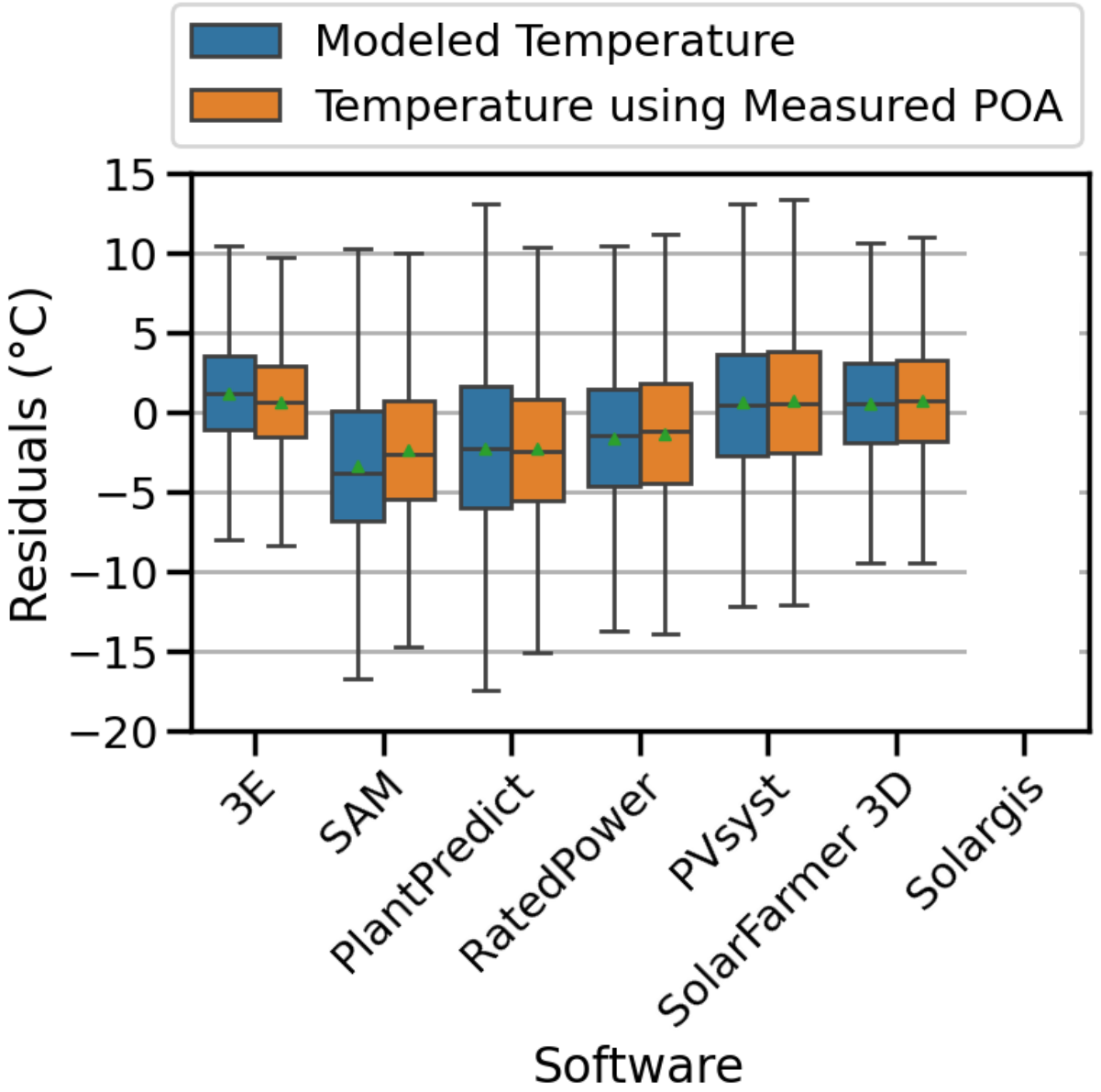


Possible incorrect array orientation, or an issue with the sun position algorithm

Sub-hourly Albuquerque, 15.4 kW

Temperature Modeling

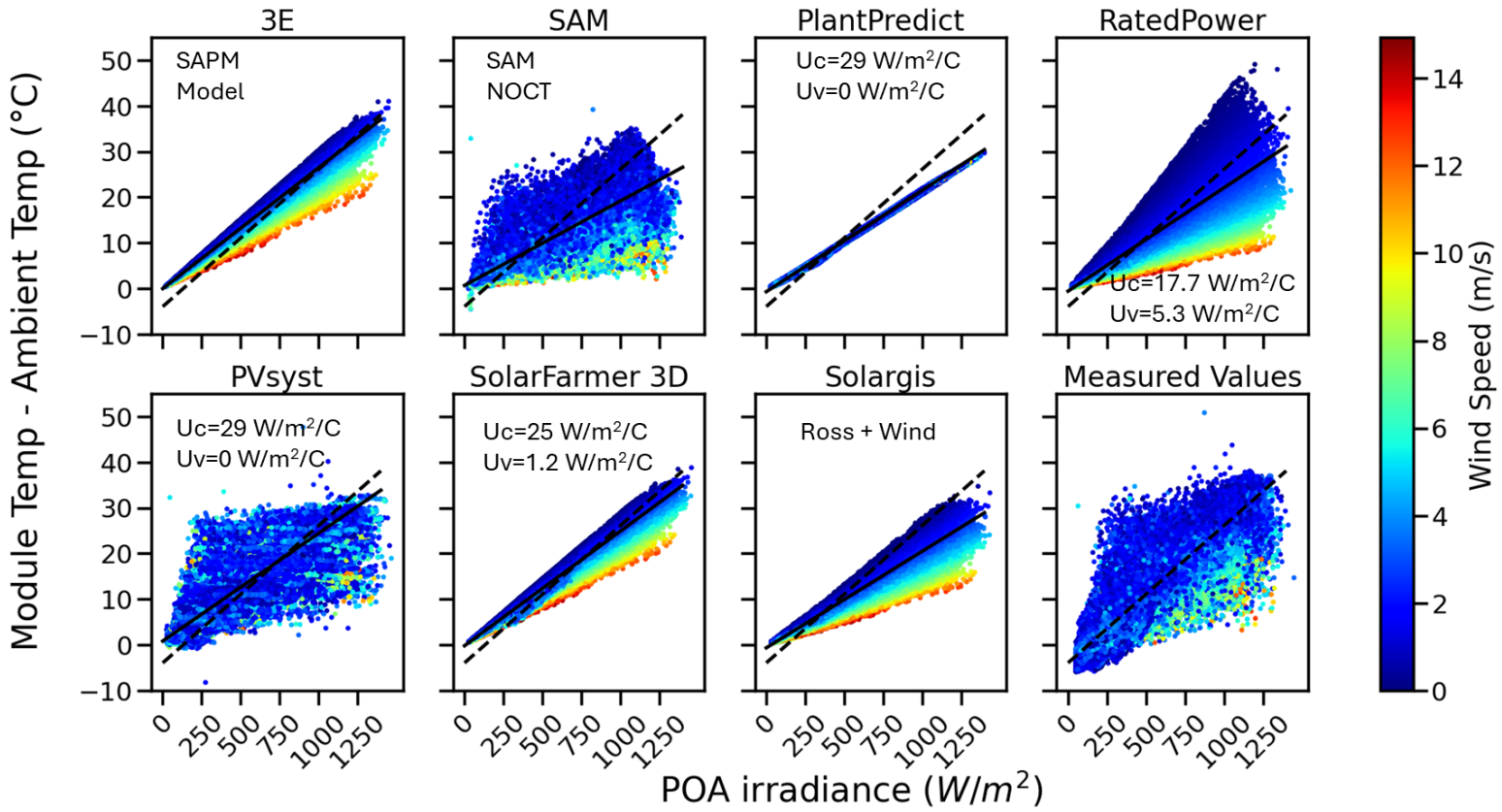
- Replicating User's modeled temperature with measured POA showed minimal differences
- Delta of residuals varied from – 0.11°C to 1.16°C
- Majority of error in Tmod modeling is not from their POA modeling; Tcell customization?
- Solargis differs since their Tmod was not able to be replicated exactly due to additional wind considerations



Sub-hourly Albuquerque, 15.4 kW

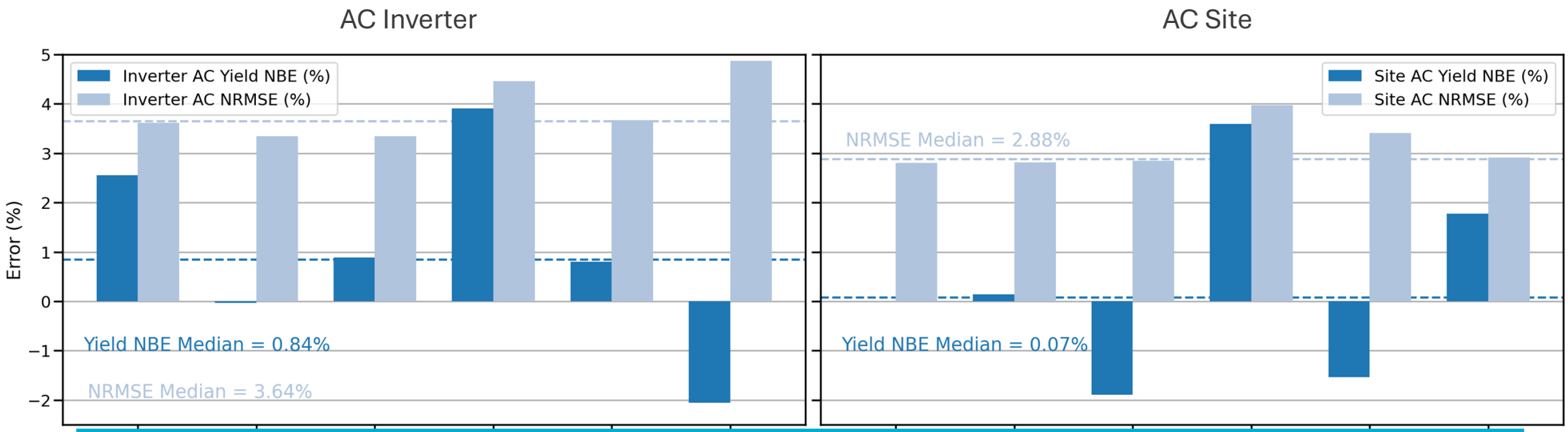
Temperature Modeling

- Scatter in measured but not in modeled because transience is only considered by SAM
- Uc, Uv assumptions in PVsyst Tcell models heavily influenced results: larger Uv = larger spread due to wind speed



Sub-hourly Albuquerque, 15.4 kW

AC Annual Energy Yield



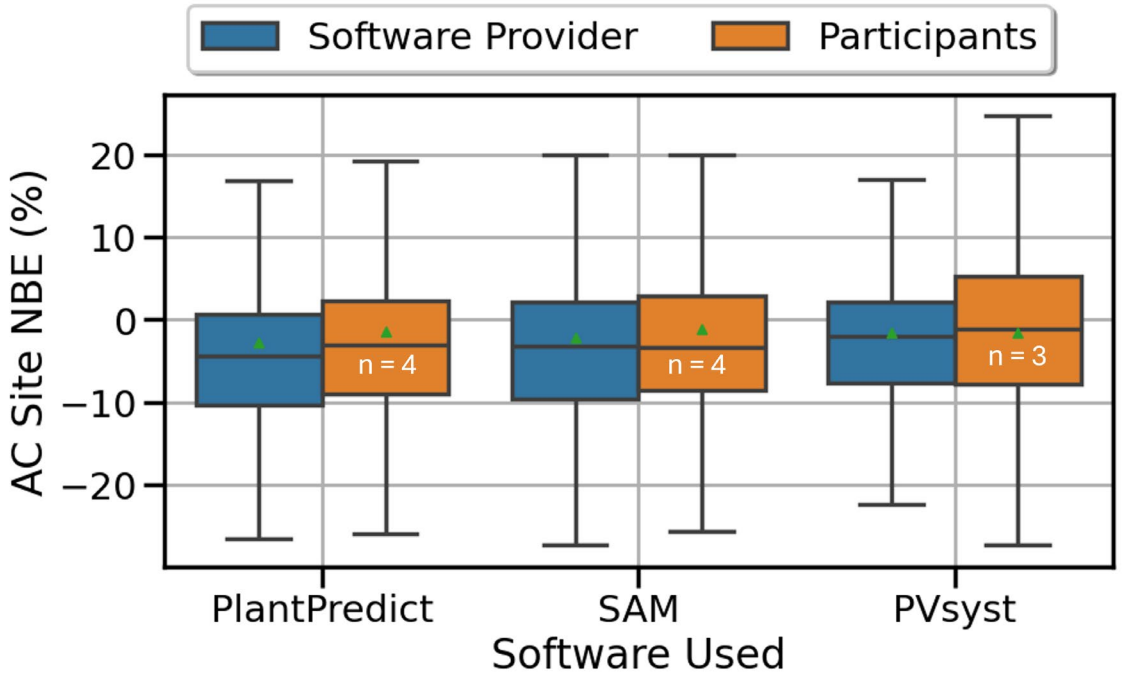
Final results with revealed software names will be provided in the journal publication

All software were within ±4% for AC inverter & site level annual energy yield NBE
AC power NRMSE within 5% and MBE within ±2.8%

Sub-hourly Germany, 14.5 MW

Reproducibility: Software Providers vs Their Participants

- Comparing estimates from PVPMC's open comparison against software providers
- Delta of AC Site NBE varied from 0.07% to -1.35%
- There is relatively good agreement between users and software providers



Sub-hourly Germany, 14.5 MW

Software Provider Comparison Table

Software	SolarFarmer	PlantPredict	SAM	PVsyst	RatedPower	3E	Solargis
API/SDK	API	API	SDK	No	No	No	No
System Mounting Types	Fixed & SAT Terrain Following	Fixed & SAT	Fixed, SAT, & DAT	Fixed, SAT*, & DAT Terrain Following*	Fixed & SAT	Fixed, SAT, & DAT	Fixed & SAT
Module Temp. Model	PVsyst	PVsyst	NOCT or Heat Transfer	PVsyst	PVsyst	SAPM Cell	NOCT
Considers Temp. Transience?	No	No	Yes	No	No	No	No
3D / Shade Scenes Accepted	PVC	PVC or PVJ	PVsyst scenes, Suneye, Solar Pathfinder	PVC, H2P, DAE	None	None	KML
Soiling Loss Default	0% - Fixed	2% - Fixed	5% - Fixed	0% - Fixed	2% - Fixed	1% - Fixed	Varies by Month

- 50+ questions compiled into table about weather & irradiance calculations, AC & DC system calculations, default derate values, etc.

Conclusions

- Software tools compare well against each other with annual AC yield within ±4%; more detailed site information would probably lower this even further
- Good reproducibility: PlantPredict, SAM, and PVsyst users are in relatively good agreement with the software providers
- These outcomes hold true for relatively flat terrains with monofacial fixed tilt systems
- We still have work to do validating irradiance and shading models, uneven terrains, bifacial tracked systems….

Try our PVPMC datasets

Well-documented PVPMC validation datasets can be downloaded at:

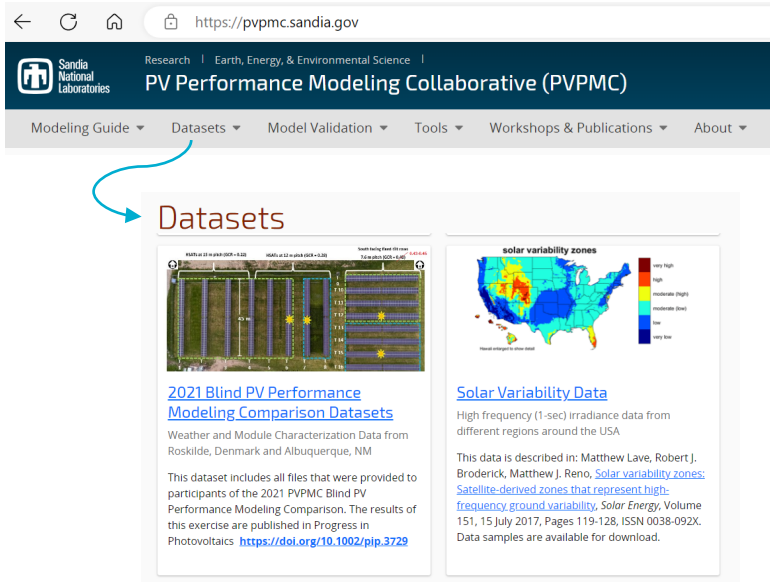
https://pvpmc.sandia.gov

https://datahub.duramat.org/project/about/pvpmc

2021 blind PVPMC datasets:

https://doi.org/10.21948/1970772

https://datahub.duramat.org/en/dataset/pv-performance-modeling-data



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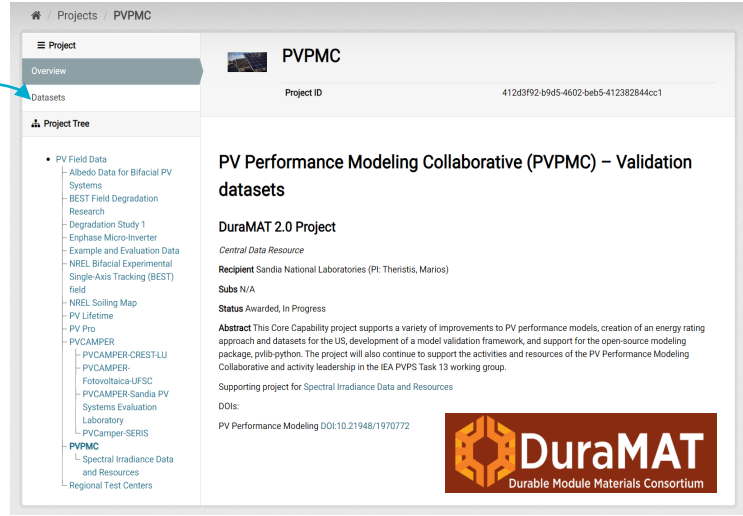

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Please join the PVPMC at https://pvpmc.sandia.gov/ Contribute, and help increase confidence in PV system performance

On behalf of the PVPMC team, thank you!

Marios Theristis
mtheris@sandia.gov

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